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(54) PROCESS FOR THE CONTINUOUS PURIFICATION OF WASTE WATERS

(71) We, H. P. HEFERMEHL S.A., of 58 Avenue Général-Guisan, CH-1800 Vevey, Switzerland, a Body-Corporate organised under the laws of Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with a process for the continuous purification of effluent water, as well as with a plant for carrying out the process.

The large amounts of agricultural effluent water and, in particular, of dung water, is always a great problem in agriculture, as well as in the protection of open waters, such as ponds, lakes, rivers, canals and the like. The agricultural utilisation of dung water is of increasing difficulty because of the shortage of suitable grass land for disposal thereof and because of increasing costs for the transport thereof. The requirements for the protection of open waters are becoming more and more stringent in order to prevent the devastating effect of the contamination of open waters by agricultural effluent water.

The above-mentioned difficulties, on the one hand, and the more stringent requirements, on the other hand, have in recent years, resulted in an ever-increasing demand for a process for the economic decontamination of this effluent water. The recent tendency towards intensification and rationalisation of breeding and stock animals has made this need even greater because the land needed for economic utilisation, which, according to the present regulations in some countries, must be, for example, at least 1 hectare per 10 stock pigs, is, in the large majority of cases, certainly not available.

Regulations concerning the storage of dung water before disposal thereof also necessitate a highly uneconomic investment for middens effluent water containing dung water into a public clarification plant is not permitted because of the excessively high content of organic materials which would result therefrom and because of the danger of blocking up the drains and sewage systems.

The clarification of dung water and of effluent water containing dung water has not been successful in previously known total oxidation plants and has also proved to be uneconomical. For the organic material content of dung water, there have been measured BON_5 values of up to 20,000 mg/litre (biochemical oxygen need, Index 5:5 days). On average, this value is about 15,000 mg./litre, i.e. is about 60 times higher than in the case of town effluent water. When, in addition, the dung water or effluent water containing dung water also contains drainage water from fodder silos, then these values can even be significantly higher. This explains the excessive load placed on the previously known plant.

The running off of the agricultural effluent water pre-clarified in a total oxidation plant, into an absorption tank containing evergreen plants has also not proved to be useful since the evaporation of the water taken up by the plants, as well as the assimilation of the salts contained therein, is too dependent upon the weather.

The drying of total dung waters by evaporation of the water contained therein, which as a rule amounts to 95—97%, is uneconomic and brings with it the danger of atmospheric contamination and malodours, even if such a process is to be regarded as being completely satisfactory from the point of view of protecting open waters.

The present invention is based upon the consideration that a previous mechanical separation of the solid materials suspended in the dung water or in other agricultural effluent water results in a considerable reduction of the load upon the clarification plant

ous purification of effluent water, wherein effluent water to be purified is subjected to a first separation process for the removal of coarse solid materials, the pH value of the water being measured before, during or after said removal of coarse solid materials and, if necessary, adjusted to a neutral or acidic range after said removal of coarse solid materials, a flocculation and/or precipitation agent being added to the water which has been freed from coarse solid materials, followed by separation of the flocculated materials from the liquid phase.

According to a modification of the process of the present invention, when it is necessary to adjust the pH to a neutral or acidic value, this can be carried out before, during or after the removal of coarse solid materials with an acid or with a mixture of an acid and a salt, for example with sulphuric acid, optionally in admixture with aluminium sulphate.

The process according to the present invention will now be explained in more detail, with reference to the accompanying drawings, in which:—

Figure 1 illustrates the principle of the process; and

Figure 2 is a flow diagram of a plant for carrying out the process according to Figure 1.

Effluent water to be clarified, in the form of wash water containing excrement, urine, foodstuff residues, domestic and silo effluent water and the like, is collected in a collection pit (1) which is preferably large enough to hold at least the amount of effluent water produced in the course of 24 hours. If, in the byres and stalls, scattered straw is used and, in addition, domestic waste waters are also to be treated, then it is recommended to provide a disintegrator (not illustrated) prior to the collection pit.

A stirrer (2) prevents the deposition of heavy solid materials in the pit.

By means of a volumetric pump (3), the effluent water to be clarified is removed from the collection pit (1) and passed to a sieve machine (4). This machine (4) separates out all suspended solid materials down to a minimum particle size of, for example, 50μ. Vibration and shaking sieves have proved to be best for this first mechanical separation step. The moisture content of the solid materials thereby separated out is between 75—85%.

We have now, surprisingly, found that by means of the sieving out of the suspended solid materials in the sieving machine (4), the biological loading, for example, in pig breeding, is reduced by 50—70%, i.e. the amount

The moist solid materials removed by the sieving machine (4) are either conveyed to a compost heap, possibly by means of a conveyor belt, or are fed to a thermal drier (18) and from there passed, for example, by means of a pneumatic transport device to a sack-filling cyclone (19). Experience has shown that the solid materials obtained with a moisture content of 75—85% can be composted without difficulty or can be dried in suitable thermal driers, with comparatively low cost, to a residual moisture content of 8—15%. The amount of water which has thereby to be evaporated is only a fraction of that which has to be evaporated in a total drying process and is, therefore, economically acceptable.

By means of such a thermal drying, valuable fertiliser materials are obtained of practically unlimited storability, together with a substantial reduction of the transport costs to a dry fertiliser factory for the purpose of mixing with other natural fertilisers or with artificial fertiliser.

For the further clarification of the liquid phase emerging from the sieving machine (4), chemicals are continuously admixed therewith, in a reaction path (5) which contains a pH measuring device, by means of dosing pumps (17), these chemicals serving to regulate the pH value of the liquid phase. At the same time, chemicals for flocculating and precipitating out the suspended, colloidal or dissolved materials, which constitute organic contamination of the water, are fed into the reaction path (5). However, it is also possible to measure and, if necessary, to regulate the pH before or in the sieving machine (4), as is indicated by the chain line in Figure 1.

The precipitation of the fine materials which are still present in a suspended state after the preclarification, as well as the colloidal and dissolved materials, is carried out in the acid or neutral range, preferably at a pH value of 4.5—7.0, with the use of appropriate flocculation and precipitation agents.

As flocculation agents, there are preferably used high molecular weight polymers, for example homo- and/or co-polymers of acrylic acid, as well as ionic polyelectrolytes and also non-ionic, anionic and cationic polymers. Examples of such polymers include polyacrylates, polymethacrylates, polyacrylamides, polyethylene oxides, polyamines, co-polymers of vinyl acetate or styrene with maleic anhydride, quaternary ammonium compounds, polyvinyl alcohol and polyethylene oxide.

As precipitation agents, there are advan-

purified effluent water. Very favourable results have been achieved with a pH value regulation and simultaneous precipitation with a mixture of salt and acid, preferably with a mixture of aluminium sulphate and sulphuric acid. It is surprising that a precipitation can be successfully carried out at a neutral or acidic pH value because the proteins present exhibit, with decreasing pH value, increasingly strong contraction properties which are the greatest at the isoelectric point of the proteins. By adding a salt and an acid, especially aluminium sulphate sulphuric acid, for carrying out the precipitation and pH regulation, the slight basicity of the aluminium sulphate is completely suppressed and the adsorption by and cohesion between the particles is substantially increased. This favours the influence of the flocculation agent, especially of ionic polyelectrolytes.

The stock solutions of these products are periodically stirred up, for example once a week, in the containers (15) by means of stirring devices (16).

Due to the precipitating out of the suspended, colloidal and dissolved materials, a clearly visible formation of flocculates occurs, these flocculates being separated off in a flotation trough (6). The flotation of the flocculates is substantially promoted by aeration or by application of an electrical field. By means of this procedure, there is obtained a clear liquid, the BON_5 load of which is still about 1,000 mg./litres. It has a pale yellow-brown colour and still has a somewhat unpleasant smell.

It is also possible to remove the flocculates by sieving, sedimentation and/or filtration.

In many cases, it is possible to pass the thus treated water to a conventional water purification plant or to spray it on to land. Conventional plants have, by definition, a biological part. However, in most cases, clarification must be carried out still further before the purified water can be passed into a sewage system.

The periodically and continuously exhausted flocculates can again be returned to the sieving machine (4) or can be passed directly into drier (18).

The outflow from the flotation trough (6) is collected in an intermediate container (7) and passed from there, by means of a volumetric pump (8), to a wash column (9). In this, the water is brought into intimate contact, in countercurrent, with a definite amount of ionised air, which has been enriched with ozone in an ozoniser (10) by ionisation, ozone thereby acting self-catalytically for the oxidation of compounds present in the waste water the water are further strongly decomposed and, at the same time, a substantial sterilisation of the purified water is achieved. Analyses have shown that the number of microorganism in water ozonised in this manner is extremely small and *Coli bacilli* can no longer be detected. Furthermore, this strong oxidation can be achieved not only by ozone but also by or additionally by peroxy compounds, for example, hypochlorous acid, peroxy acids and/or the salts thereof.

Due to the action of the ozone and/or other oxidation agents, organic materials still present are decomposed, which again results in a slight turbidity in the clarified water due to suspended decomposed materials. The water coming from the oxidation stage must, therefore, be subjected to a fine filtration, for which purpose there are preferably used highly active adsorption agents, such as activated charcoal, kaolin, fullers' earth or ceramic filter candles.

As a result of the pH value regulation applied at the commencement of the process and due to the influence of the precipitating agent employed, the pH value of the filtrate flowing from the wash column (9) can be below 6.5. Therefore, a further pH control must be provided, possibly automatically, and, if necessary, a neutralisation of the filtrate. For this purpose, the filtrate is preferably passed over a layer of chalk chips.

The water emerging from the wash column (9) flows, for this purpose, into an intermediate container (11), from which it is passed, by means of a volumetric pump (12), through a fine filter (13).

The clarifying power of this filter (13) is sufficient to satisfy the requirements for direct disposal into a sewage system (not shown). The end product is, as a rule, a colourless and odourless water, the average BON_5 of which, on average, does not exceed 20 mg./litre and which is also below the other maximum limits for feeding into a sewage system.

Furthermore, the water is practically free of micro-organisms and can, therefore, be used again for cleaning stalls, byres and the like, which is of considerable importance in areas where there is a shortage of water. In addition, this recycling of the purified water constitutes a considerable relief of the load on the sewage system.

However, it is recommended to store this clarified water in storage troughs in order to be able continuously to check the quality of the clarified water, for example, by means of a turbidity measurer and/or a colorimeter and/or a conductivity meter, and a part thereof can again be passed by means of a pump to stalls and byres for cleaning pur-

The following Examples are given for the purpose of illustrating the present invention:—

Example 1.

Effluent water from a dung pit is fed, by means of a pump, to the sieve machine, the pH value of the crude dung having first been determined by means of a pH measuring device and adjusted by a dosing pump to a pH value of 5.4. The pH adjustment is carried out with a mixture of aluminium sulphate and sulphuric acid. The ratio of aluminium sulphate to concentrated sulphuric acid is 10:1, referred to the dry aluminium sulphate. The acidic pH value favours the sieving action for the separation of the suspended solid materials.

The filtrate from the sieving machine is continuously mixed, by means of a dosing pump, with a polyacrylate as flocculation agent, a strong flocculation effect thereby being achieved. The flocculation agent is added in a concentration of 0.05%.

The flocculate is floated out into an aerated flotation trough. The considerably purified flotation water is now treated with ozone. Subsequently, the water is clarified by filtration through a ceramic filter with a pore size of 50—200 μ.

Analysis data of the initial effluent water:

proportion of suspended solid materials: 3.45%
$KMnO_4$ value 12560 mg. $KMnO_4$/l.

Filtered and clarified water:

proportion of suspended solid material: 0.018%
$KMnO_4$ value 50 mg. $KMnO_4$/l.

The purification effect achieved is 99.6%.

Amount of aluminium sulphate/sulphuric acid used: 5 kg./m^3

Amount of flocculation agent (polyacrylate) used: 0.020 kg./m^3

Example 2.

After measurement of its pH value, a mechanically pre-purified suspension was adjusted with sulphuric acid to a pH of 4.8. Thereafter, a mixture of aluminium sulphate and ferric chloride was added and, directly thereafter, a polyacrylamide was added as flocculation agent. The flocculated solid materials were removed by means of a kieselguhr filter and the filtrate further treated as in Example 1.

The requirement of chemicals was about the same as in Example 1. The purification effect in this case was 98.5%.

The water purified in the manner described in both of the above Examples can

of effluent water, wherein effluent water to be purified is subjected to a first separation process for the removal of coarse solid materials, the pH value of the water being measured before, during or after said removal of coarse solid materials and, if necessary, adjusted to a neutral or acidic pH value after said removal of coarse solid materials, a flocculation and/or precipitation agent being added to the water which has been freed from coarse solid materials, followed by separation of the flocculated materials from the liquid phase.

2. Modification of the process according to claim 1, wherein, when it is necessary to adjust the pH to a neutral or acidic value, this is carried out before, during or after the removal of coarse solid materials with an acid or with a mixture of an acid and a salt.

3. Process according to claim 1 or 2, wherein the water obtained after separation of the flocculated materials is subjected to a biological after-treatment.

4. Process according to any of the preceding claims, wherein the water obtained after separation of the flocculated materials is subjected to an oxidation treatment.

5. Process according to any of the preceding claims, wherein the flocculated materials are separated by flotation and/or sieving, sedimentation or filtering.

6. Process according to any of the preceding claims, wherein the pH value of the water is maintained within the limits of 4.5—7.0.

7. Process according to any of the preceding claims, wherein the pH value regulation is carried out by the addition of an acid.

8. Process according to claim 7, wherein the acid used is sulphuric acid.

9. Process according to any of the preceding claims, wherein the coarse solid materials are separated before the flocculation and precipitation by means of a vibration or shaking sieve or by means of a filter.

10. Process according to any of the preceding claims, wherein the flocculation agent used is an ionic polyelectrolyte.

11. Process according to claim 10, wherein the flocculation agent is a homo- or co-polymeric polyacrylate and/or amide, and/or a cationic polymer and/or a non-ionic polymer.

12. Process according to claim 11, wherein the cationic polymer is a quaternary ammonium compound.

13. Process according to claim 11, wherein the non-ionic polymer is polyvinyl alcohol or

compound for the reduction of the biochemical oxidation requirement.

15. Process according to claim 14, wherein the peroxy compound is hyperchlorous acid and/or a peroxy acid and/or a salt thereof.

16. Process according to any of claims 4—15, wherein the oxidatively treated, clarified liquid is filtered, optionally with the use of an adsorption agent.

17. Process according to claim 16, wherein the filtration is carried out with the use of activated charcoal, fullers' earth and/or ceramic filter materials.

18. Process according to any of the preceding claims, wherein the clarified liquid, before disposal or further use, is again subjected to a pH control and, if necessary, the pH value is adjusted, for example, automatically.

19. Process according to any of the preceding claims, wherein the clarified liquid, before disposal or further use, is subjected to turbidity and/or colorimetric and/or conductivity measurement.

20. Process according to any of the preceding claims, wherein the separated coarse solid materials are dried separately or in admixture with other materials to a residual moisture content of 8—15%.

21. Process according to any of the preceding claims, wherein the effluent water to be treated is agricultural effluent water which contains at least excrement, especially animal excrement, and wash water, as well as domestic effluent water and waste from stalls and byres.

22. Process according to claim 21, wherein drainage liquid from fodder silos is also admixed with the effluent water.

23. Process according to claim 1 for the purification of effluent water, substantially as hereinbefore described and exemplified.

24. Water, whenever purified by the process according to any of claims 1—23.

25. Plant for the carrying out of the process according to claim 1 or 2, comprising a collection vessel for effluent water to be purified, a shaking or vibration sieve for the separation of solid materials, a dosing device for the continuous addition of flocculation and/or precipitation agents, a flotation device for the removal of flocculates or precipitates, an oxidation chamber for clarified liquid, with filter means for oxidised clarified liquid and means for determining and adjusting the pH value.

26. Plant according to claim 25, which comprises a drying device for drying separated solid materials.

27. Plant according to claim 25 or 26, substantially as hereinbefore described and exemplified.

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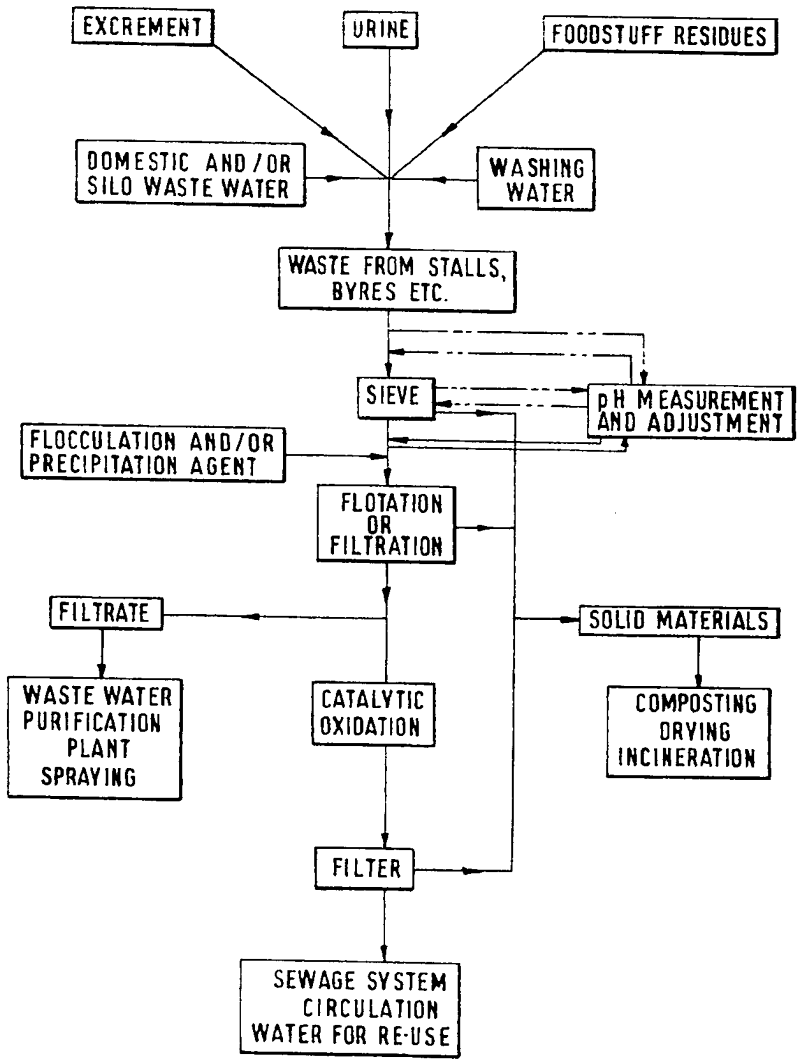
FIG.1


EXCREMENT
URINE
FOODSTUFF RESIDUES
DOMESTIC AND/OR SILO WASTE WATER
WASHING WATER
WASTE FROM STALLS, BYRES ETC.
SIEVE
pH MEASUREMENT AND ADJUSTMENT
FLOCCULATION AND/OR PRECIPITATION AGENT
FLOTATION OR FILTRATION
FILTRATE
SOLID MATERIALS
WASTE WATER PURIFICATION PLANT SPRAYING
CATALYTIC OXIDATION
COMPOSTING DRYING INCINERATION
FILTER
SEWAGE SYSTEM CIRCULATION WATER FOR RE-USE

1321106 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG. 2